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(54) **METHODS AND APPARATUSES FOR POWER SAVING BY DETECTING EMPTY SYMBOLS**

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(52) **U.S. Cl.**
CPC ***H04W 52/0245*** (2013.01)

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CPC H04W 52/0245; H04W 72/0446; H04W 76/28
See application file for complete search history.

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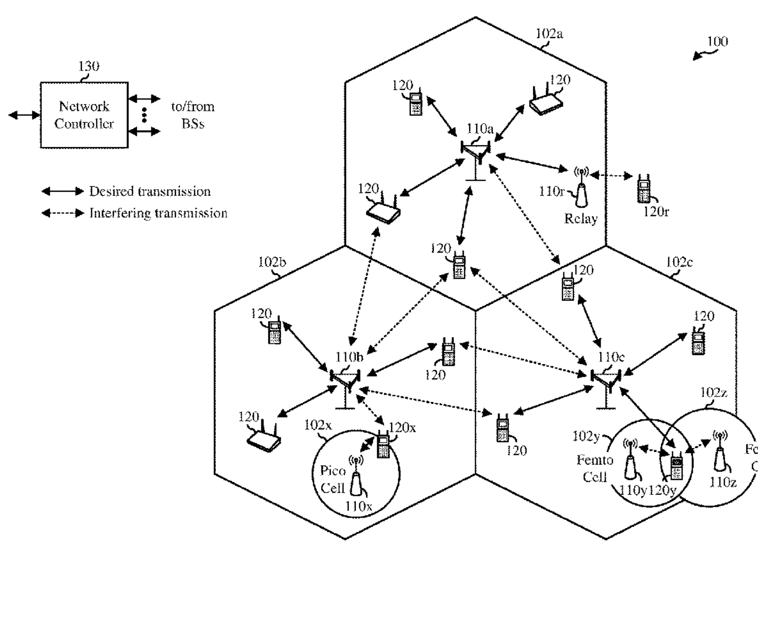
(57) **ABSTRACT**

Method and apparatus are provided for power saving by detecting empty symbols. In accordance with some implementation, a UE may determine that a data channel is not allocated to it by determining that there is no beam directed to it and there was no prior resource allocation to it. The UE upon such determination may enter sleep mode until the start of the next scheduling unit. This may result in reduction in power consumption compared to entering sleep mode after demodulating and decoding the control channel.

30 Claims, 6 Drawing Sheets



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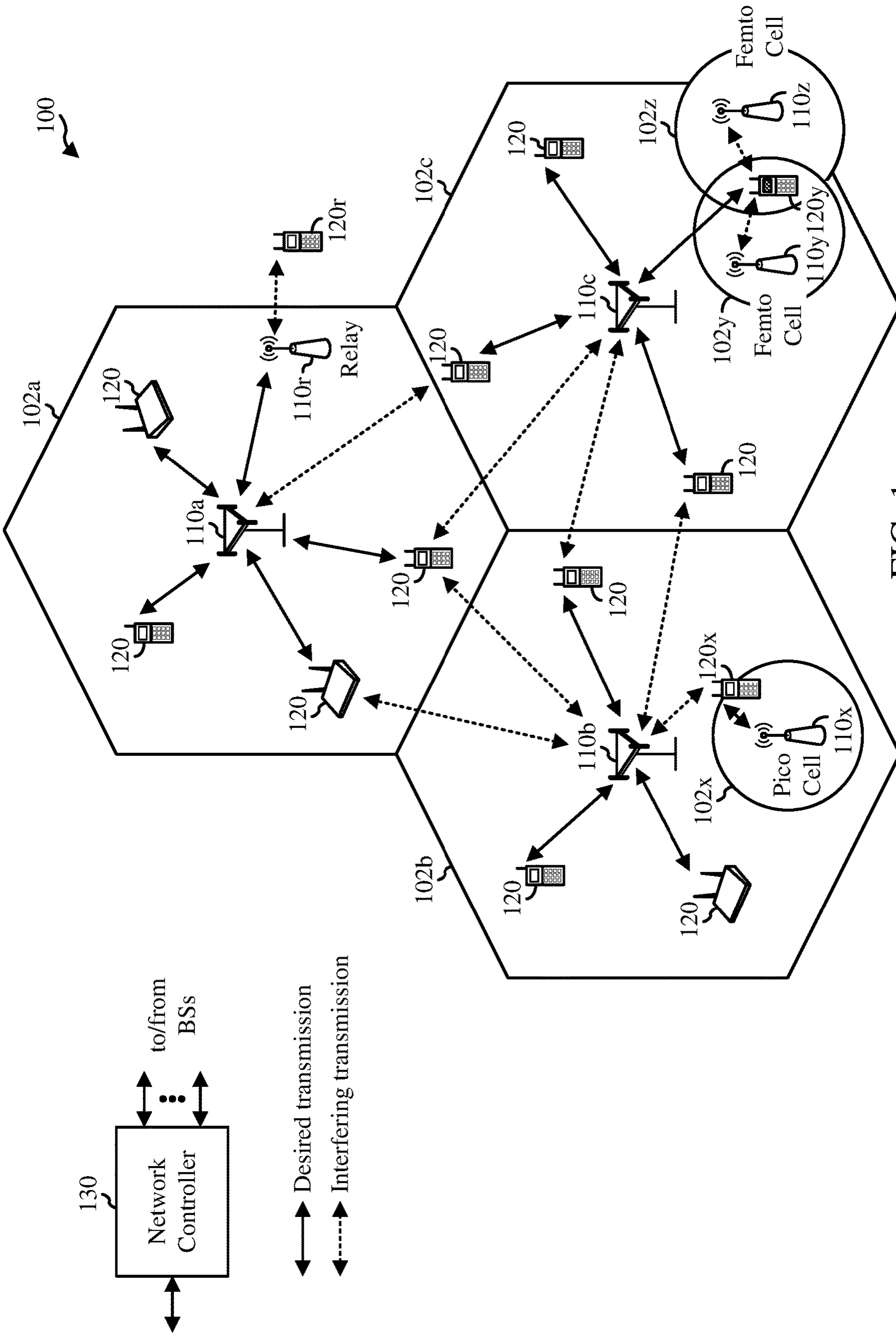

100
102a
102b
102c
102x
102y
102z
110a
110b
110c
110r
110x
110y
110z
120
120r
120x
120y
Relay
Femto Cell
Femto Cell
Pico Cell
130
Network Controller
to/from BSs
Desired transmission
Interfering transmission

FIG. 1

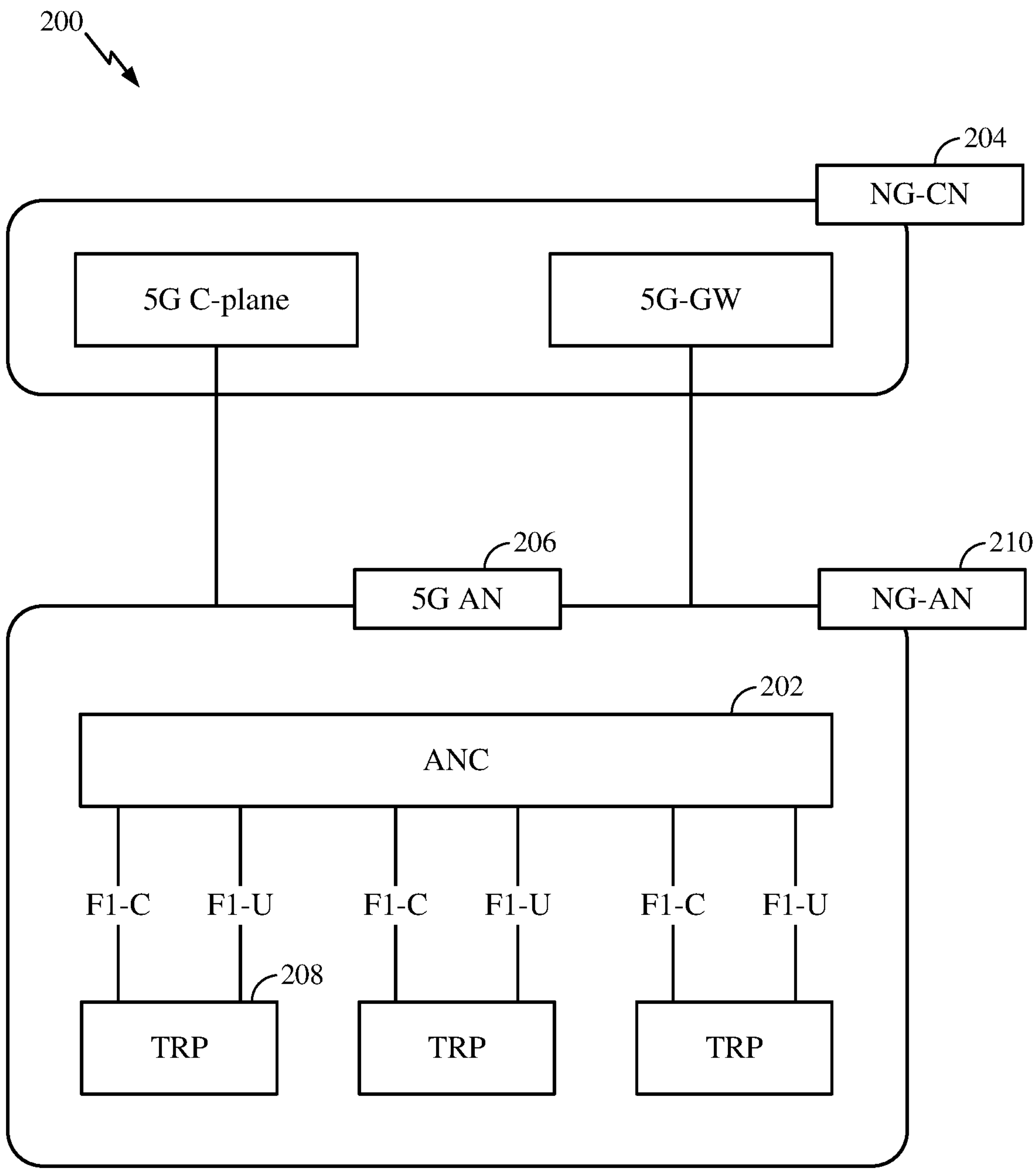

200
204
NG-CN
5G C-plane
5G-GW
206
5G AN
210
NG-AN
202
ANC
F1-C
F1-U
F1-C
F1-U
F1-C
F1-U
208
TRP
TRP
TRP

FIG. 2

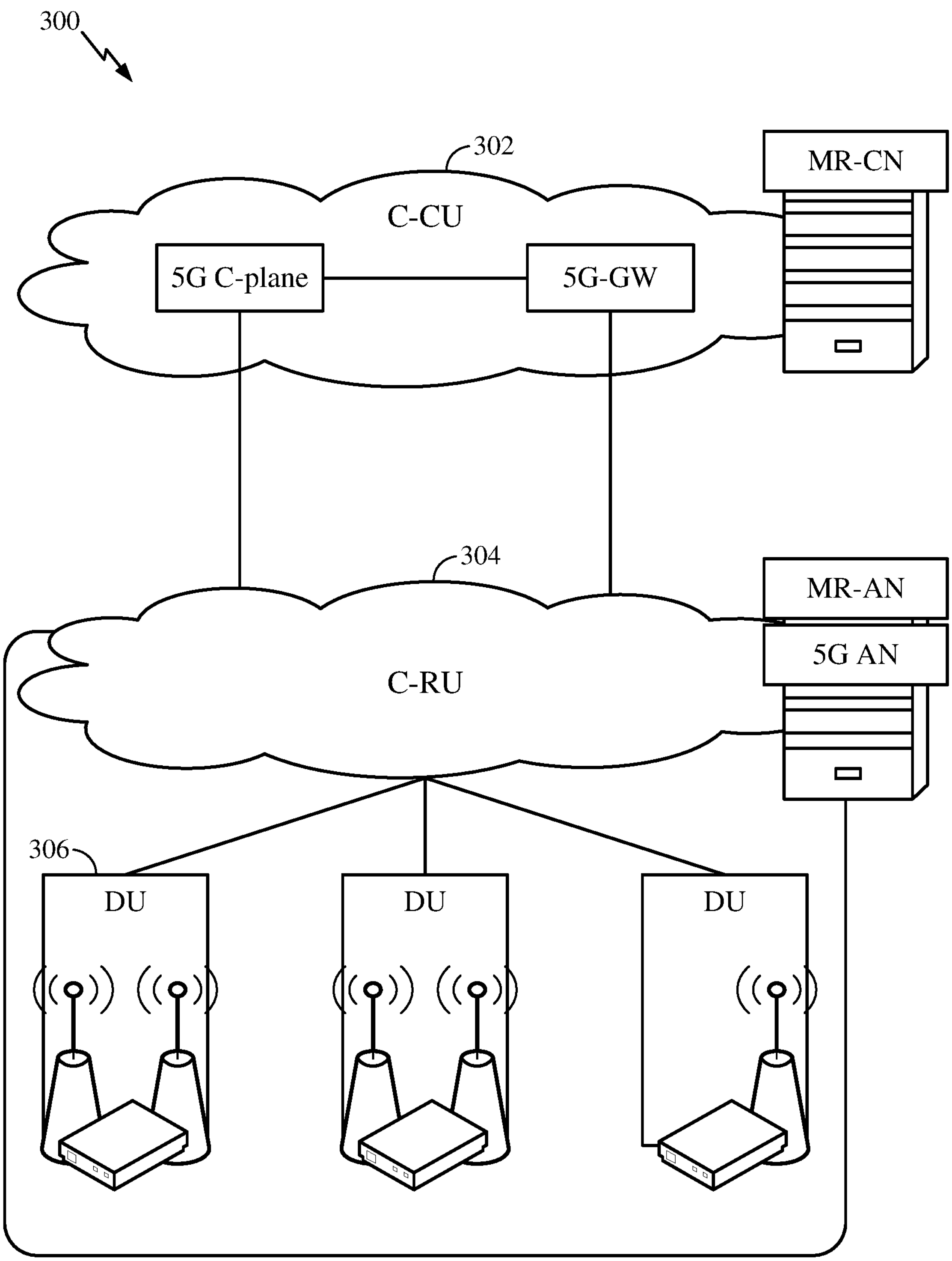
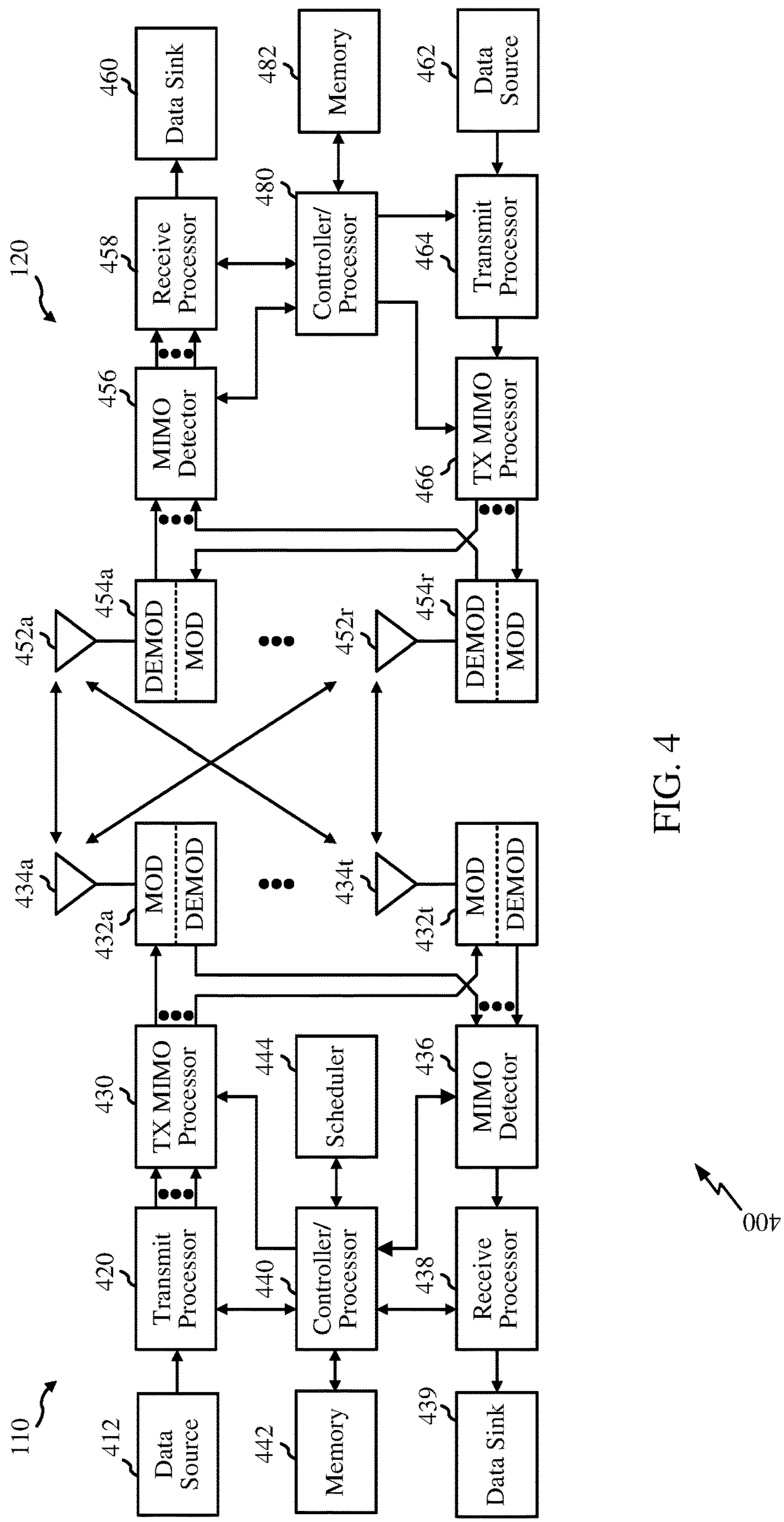


FIG. 3



110
412
Data Source
442
Memory
439
Data Sink
420
Transmit Processor
440
Controller/ Processor
438
Receive Processor
430
TX MIMO Processor
444
Scheduler
436
MIMO Detector
432a
MOD
DEMOD
432t
434a
434t
452a
452r
454a
454r
DEMOD
MOD
456
MIMO Detector
466
TX MIMO Processor
458
Receive Processor
480
Controller/ Processor
464
Transmit Processor
460
Data Sink
482
Memory
462
Data Source
120
400

FIG. 4

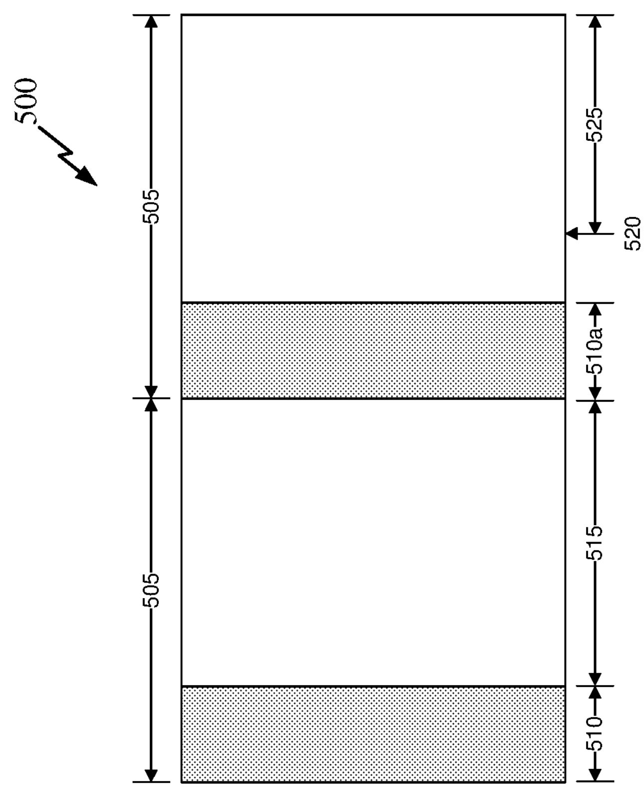


FIG. 5

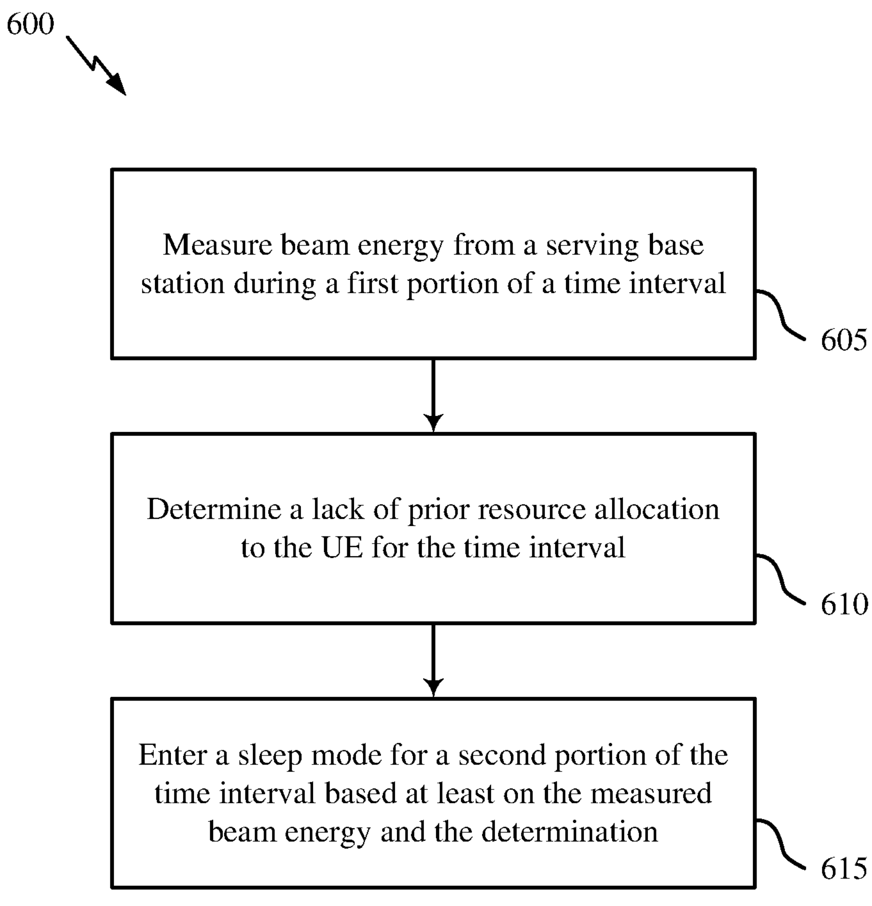

600
Measure beam energy from a serving base station during a first portion of a time interval
605
Determine a lack of prior resource allocation to the UE for the time interval
610
Enter a sleep mode for a second portion of the time interval based at least on the measured beam energy and the determination
615

FIG. 6

METHODS AND APPARATUSES FOR POWER SAVING BY DETECTING EMPTY SYMBOLS

TECHNICAL FIELD

The present disclosure relates generally to wireless communication systems, and more particularly, to methods and apparatus for power saving by sleeping.

INTRODUCTION

Wireless communications systems are widely deployed to provide various types of communication content such as voice, video, packet data, messaging, broadcast, and so on. These systems may be capable of supporting communication with multiple users by sharing the available system resources (e.g., time, frequency, and power). Examples of such multiple-access systems include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, and orthogonal frequency division multiple access (OFDMA) systems.

These multiple access technologies have been adopted in various telecommunication standards to provide a common protocol that enables different wireless devices to communicate on a municipal, national, regional, and even global level. An example telecommunication standard is 5G New Radio (NR). 5G NR is part of a continuous mobile broadband evolution promulgated by Third Generation Partnership Project (3GPP) to meet new requirements associated with latency, reliability, security, scalability (e.g., with Internet of Things (IoT)), and other requirements. Some aspects of NR may be based on the Long Term Evolution (LTE) standard.

A user equipment (UE) in wireless communication systems may have limited power and thus there is a need to conserve power. A UE may conserve power by sleeping at certain time intervals, e.g., discontinuous reception (DRX), micro-sleep. There exists a need for further improvements in power conservation.

SUMMARY

The systems, methods, and devices of the disclosure each have several aspects, no single one of which is solely responsible for its desirable attributes. Without limiting the scope of this disclosure as expressed by the claims which follow, some features will now be discussed briefly. After considering this discussion, and particularly after reading the section entitled "Detailed Description" one will understand how the features of this disclosure provide advantages that include improved communications between access points and stations in a wireless network.

Certain aspects of the present disclosure provide a method for wireless communications by a user equipment (UE). The method generally includes measuring a beam energy from a serving base station (BS) during a first portion of a time interval, determining a lack of prior resource allocation to the UE for the time interval, and entering a sleep mode for a second portion of the time interval based at least on the measured beam energy and the determination. In an aspect, the time interval may be a subframe, a slot, or a mini-slot. In an aspect, the first portion may be a set of symbols indicating control information, e.g., PDCCH, ePDCCH. In an aspect, entering a sleep mode may be based at least on the measured beam energy being indicative of the beam not directed to the UE. In an aspect, a sleep mode may comprise selectively de-activating radio frequency (RF) components of the UE. In an aspect, entering a sleep mode may further be based on a measurement of signal compared to a measurement of noise.

Aspects generally include methods, apparatus, systems, computer readable mediums, and processing systems, as substantially described herein with reference to and as illustrated by the accompanying drawings.

To the accomplishment of the foregoing and related ends, the one or more aspects comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative features of the one or more aspects. These features are indicative, however, of but a few of the various ways in which the principles of various aspects may be employed, and this description is intended to include all such aspects and their equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above-recited features of the present disclosure can be understood in detail, a more particular description, briefly summarized above, may be had by reference to aspects, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only certain typical aspects of this disclosure and are therefore not to be considered limiting of its scope, for the description may admit to other equally effective aspects.

FIG. **1** is a block diagram conceptually illustrating an example telecommunications system, in accordance with certain aspects of the present disclosure.

FIG. **2** is a block diagram illustrating an example logical architecture of a distributed RAN, in accordance with certain aspects of the present disclosure.

FIG. **3** is a diagram illustrating an example physical architecture of a distributed RAN, in accordance with certain aspects of the present disclosure.

FIG. **4** is a block diagram conceptually illustrating a design of an example base station (BS) and user equipment (UE), in accordance with certain aspects of the present disclosure.

FIG. **5** is a diagram illustrating an example micro sleep procedure.

FIG. **6** is a diagram illustrating an example operation of a wireless communication device for power saving by detecting empty symbols.

To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements disclosed in one aspect may be beneficially utilized on other aspects without specific recitation.

DETAILED DESCRIPTION

During connected state, a user equipment (UE) may conserve power by sleeping during time intervals the UE knows it will not receive data from a serving base station (BS). In a scheduling unit, a UE may receive downlink control channel (CCH) which may carry, along with other information, whether the subsequent downlink data channel (DCH) is assigned to the UE or to other UEs. A UE may sleep during DCH if the UE determines from the CCH that the DCH is not allocated to it. Such short sleep from when the UE determines that the DCH is not allocated to it until the start of the next scheduling unit is called micro-sleep.

However, a UE may require some time to demodulate and decode CCH which incurs delay in determining whether the DCH is allocated to it after receiving CCH. This delay may reduce the time that the UE can sleep and hence may reduce the extent that a UE may conserve power.

In certain aspects, it may be desirable to enter sleep mode earlier to further reduce UE power consumption. In certain aspects, it may be possible to determine whether DCH is allocated to the UE without demodulating and decoding CCH. In high band frequencies (e.g., mmW), a serving BS may use multiple narrow analog beams to cover an area. The serving BS may direct a beam towards the UE if the serving BS intends to transmit control and/or data channels. If the serving BS does not have any control and/or data channel to transmit to the UE, the serving BS may not direct a beam towards the UE. It may be desirable to use such behavior of the serving BS in high band frequencies to enter sleep mode earlier to further conserve UE power.

The following description provides examples, and is not limiting of the scope, applicability, or examples set forth in the claims. Changes may be made in the function and arrangement of elements discussed without departing from the scope of the disclosure. Various examples may omit, substitute, or add various procedures or components as appropriate. For instance, the methods described may be performed in an order different from that described, and various steps may be added, omitted, or combined. Also, features described with respect to some examples may be combined in some other examples. For example, an apparatus may be implemented or a method may be practiced using any number of the aspects set forth herein. In addition, the scope of the disclosure is intended to cover such an apparatus or method which is practiced using other structure, functionality, or structure and functionality in addition to or other than the various aspects of the disclosure set forth herein. It should be understood that any aspect of the disclosure disclosed herein may be embodied by one or more elements of a claim. The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects.

The techniques described herein may be used for various wireless communication networks such as LTE, CDMA, TDMA, FDMA, OFDMA, SC-FDMA and other networks. The terms "network" and "system" are often used interchangeably. A CDMA network may implement a radio technology such as Universal Terrestrial Radio Access (UTRA), cdma2000, etc. UTRA includes Wideband CDMA (WCDMA) and other variants of CDMA. cdma2000 covers IS-2000, IS-95 and IS-856 standards. A TDMA network may implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA network may implement a radio technology such as NR (e.g. 5G RA), Evolved UTRA (E-UTRA), Ultra Mobile Broadband (UMB), IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDMA, etc. UTRA and E-UTRA are part of Universal Mobile Telecommunication System (UMTS). NR is an emerging wireless communications technology under development in conjunction with the 5G Technology Forum (5GTF). 3GPP Long Term Evolution (LTE) and LTE-Advanced (LTE-A) are releases of UMTS that use E-UTRA. UTRA, E-UTRA, UMTS, LTE, LTE-A and GSM are described in documents from an organization named "3rd Generation Partnership Project" (3GPP). cdma2000 and UMB are described in documents from an organization named "3rd Generation Partnership Project 2" (3GPP2). The techniques described herein may be used for the wireless networks and radio technologies mentioned above as well as other wireless networks and radio technologies. For clarity, while aspects may be described herein using terminology commonly associated with 3G and/or 4G wireless technologies, aspects of the present disclosure can be applied in other generation-based communication systems, such as 5G and later, including NR technologies.

Example Wireless Communications System

FIG. **1** illustrates an example wireless network **100**, such as a new radio (NR) or 5G network, in which aspects of the present disclosure may be performed.

As illustrated in FIG. **1**, the wireless network **100** may include a number of BSs **110** and other network entities. A BS may be a station that communicates with UEs. Each BS **110** may provide communication coverage for a particular geographic area. In 3GPP, the term "cell" can refer to a coverage area of a Node B and/or a Node B subsystem serving this coverage area, depending on the context in which the term is used. In NR systems, the term "cell" and eNB, Node B, 5G NB, AP, NR BS, NR BS, or TRP may be interchangeable. In some examples, a cell may not necessarily be stationary, and the geographic area of the cell may move according to the location of a mobile base station. In some examples, the base stations may be interconnected to one another and/or to one or more other base stations or network nodes (not shown) in the wireless network **100** through various types of backhaul interfaces such as a direct physical connection, a virtual network, or the like using any suitable transport network.

In general, any number of wireless networks may be deployed in a given geographic area. Each wireless network may support a particular radio access technology (RAT) and may operate on one or more frequencies. A RAT may also be referred to as a radio technology, an air interface, etc. A frequency may also be referred to as a carrier, a frequency channel, etc. Each frequency may support a single RAT in a given geographic area in order to avoid interference between wireless networks of different RATs. In some cases, NR or 5G RAT networks may be deployed.

A BS may provide communication coverage for a macro cell, a pico cell, a femto cell, and/or other types of cell. A macro cell may cover a relatively large geographic area (e.g., several kilometers in radius) and may allow unrestricted access by UEs with service subscription. A pico cell may cover a relatively small geographic area and may allow unrestricted access by UEs with service subscription. A femto cell may cover a relatively small geographic area (e.g., a home) and may allow restricted access by UEs having association with the femto cell (e.g., UEs in a Closed Subscriber Group (CSG), UEs for users in the home, etc.). A BS for a macro cell may be referred to as a macro BS. A BS for a pico cell may be referred to as a pico BS. A BS for a femto cell may be referred to as a femto BS or a home BS. In the example shown in FIG. **1**, the BSs **110*a***, **110*b*** and **110*c*** may be macro BSs for the macro cells **102*a***, **102*b*** and **102*c***, respectively. The BS **110*x*** may be a pico BS for a pico cell **102*x***. The BSs **110*y*** and **110*z*** may be femto BS for the femto cells **102*y*** and **102*z***, respectively. A BS may support one or multiple (e.g., three) cells.

The wireless network **100** may also include relay stations. A relay station is a station that receives a transmission of data and/or other information from an upstream station (e.g., a BS or a UE) and sends a transmission of the data and/or other information to a downstream station (e.g., a UE or a

BS). A relay station may also be a UE that relays transmissions for other UEs. In the example shown in FIG. **1**, a relay station **110***r* may communicate with the BS **110***a* and a UE **120***r* in order to facilitate communication between the BS **110***a* and the UE **120***r*. A relay station may also be referred to as a relay BS, a relay, etc.

The wireless network **100** may be a heterogeneous network that includes BSs of different types, e.g., macro BS, pico BS, femto BS, relays, etc. These different types of BSs may have different transmit power levels, different coverage areas, and different impact on interference in the wireless network **100**. For example, macro BS may have a high transmit power level (e.g., 20 Watts) whereas pico BS, femto BS, and relays may have a lower transmit power level (e.g., 1 Watt).

The wireless network **100** may support synchronous or asynchronous operation. For synchronous operation, the BSs may have similar frame timing, and transmissions from different BSs may be approximately aligned in time. For asynchronous operation, the BSs may have different frame timing, and transmissions from different BSs may not be aligned in time. The techniques described herein may be used for both synchronous and asynchronous operation.

A network controller **130** may be coupled to a set of BSs and provide coordination and control for these BSs. The network controller **130** may communicate with the BSs **110** via a backhaul. The BSs **110** may also communicate with one another, e.g., directly or indirectly via wireless or wireline backhaul.

The UEs **120** (e.g., **120***x*, **120***y*, etc.) may be dispersed throughout the wireless network **100**, and each UE may be stationary or mobile. A UE may also be referred to as a mobile station, a terminal, an access terminal, a subscriber unit, a station, a Customer Premises Equipment (CPE), a cellular phone, a smart phone, a personal digital assistant (PDA), a wireless modem, a wireless communication device, a handheld device, a laptop computer, a cordless phone, a wireless local loop (WLL) station, a tablet, a camera, a gaming device, a netbook, a smartbook, an ultrabook, a medical device or medical equipment, a biometric sensor/device, a healthcare device, a medical device, a wearable device such as a smart watch, smart clothing, smart glasses, virtual reality goggles, a smart wrist band, smart jewelry (e.g., a smart ring, a smart bracelet, etc.), an entertainment device (e.g., a music device, a gaming device, a video device, a satellite radio, etc.), a vehicular component or sensor, a smart meter/sensor, industrial manufacturing equipment, a positioning device (e.g., GPS, Beidou, GLONASS, Galileo, terrestrial-based), or any other suitable device that is configured to communicate via a wireless or wired medium. Some UEs may be considered machine-type communication (MTC) devices or enhanced or evolved MTC (eMTC) devices. MTC may refer to communication involving at least one remote device on at least one end of the communication and may include forms of data communication which involve one or more entities that do not necessarily need human interaction. MTC UEs may include UEs that are capable of MTC communications with MTC servers and/or other MTC devices through Public Land Mobile Networks (PLMN), for example. Some UEs may be considered Internet of Things devices. The Internet of Things (IoT) is a network of physical objects or "things" embedded with, e.g., electronics, software, sensors, and network connectivity, which enable these objects to collect and exchange data. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities. Each "thing" is generally uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Narrowband IoT (NB-IoT) is a technology being standardized by the 3GPP standards body. This technology is a narrowband radio technology specially designed for the IoT, hence its name. Special focuses of this standard are on indoor coverage, low cost, long battery life and large number of devices. MTC/eMTC and/or IoT UEs include, for example, robots, drones, remote devices, sensors, meters, monitors, location tags, etc., that may communicate with a BS, another device (e.g., remote device), or some other entity. A wireless node may provide, for example, connectivity for or to a network (e.g., a wide area network such as Internet or a cellular network) via a wired or wireless communication link. In FIG. **1**, a solid line with double arrows indicates desired transmissions between a UE and a serving BS, which is a BS designated to serve the UE on the downlink and/or uplink. A dashed line with double arrows indicates interfering transmissions between a UE and a BS.

Certain wireless networks (e.g., LTE) utilize orthogonal frequency division multiplexing (OFDM) on the downlink and single-carrier frequency division multiplexing (SC-FDM) on the uplink. OFDM and SC-FDM partition the system bandwidth (e.g., system frequency band) into multiple (K) orthogonal subcarriers, which are also commonly referred to as tones, bins, etc. Each subcarrier may be modulated with data. In general, modulation symbols are sent in the frequency domain with OFDM and in the time domain with SC-FDM. The spacing between adjacent subcarriers may be fixed, and the total number of subcarriers (K) may be dependent on the system bandwidth. For example, the spacing of the subcarriers may be 15 kHz and the minimum resource allocation (called a 'resource block') may be 12 subcarriers (or 180 kHz). Consequently, the nominal FFT size may be equal to 128, 256, 512, 1024 or 2048 for system bandwidth of 1.25, 2.5, 5, 10 or 20 megahertz (MHz), respectively. The system bandwidth may also be partitioned into subbands. For example, a subband may cover 1.08 MHz (i.e., 6 resource blocks), and there may be 1, 2, 4, 8 or 16 subbands for system bandwidth of 1.25, 2.5, 5, 10 or 20 MHz, respectively.

While aspects of the examples described herein may be associated with LTE technologies, aspects of the present disclosure may be applicable with other wireless communications systems, such as NR. NR may utilize OFDM with a cyclic prefix (CP) on the uplink and downlink and include support for half-duplex operation using time division duplex (TDD). A single component carrier bandwidth of 100 MHz may be supported. NR resource blocks may span 12 sub-carriers with a sub-carrier bandwidth of 75 kHz over a 0.1 ms duration. Each radio frame may consist of 50 subframes with a length of 10 ms. Consequently, each subframe may have a length of 0.2 ms. Each subframe may indicate a link direction (i.e., DL or UL) for data transmission and the link direction for each subframe may be dynamically switched. Each subframe may include DL/UL data as well as DL/UL control data. Beamforming may be supported and beam direction may be dynamically configured. MIMO transmissions with precoding may also be supported. MIMO configurations in the DL may support up to 8 transmit antennas with multi-layer DL transmissions up to 8 streams and up to 2 streams per UE. Multi-layer transmissions with up to 2 streams per UE may be supported. Aggregation of multiple cells may be supported with up to 8 serving cells. Alternatively, NR may support a different air interface, other than an OFDM-based. NR networks may include entities such as central units (CU) and/or distributed units (DU).

In some examples, access to the air interface may be scheduled, wherein a scheduling entity (e.g., a base station) allocates resources for communication among some or all devices and equipment within its service area or cell. Within the present disclosure, as discussed further below, the scheduling entity may be responsible for scheduling, assigning, reconfiguring, and releasing resources for one or more subordinate entities. That is, for scheduled communication, subordinate entities utilize resources allocated by the scheduling entity. Base stations are not the only entities that may function as a scheduling entity. That is, in some examples, a UE may function as a scheduling entity, scheduling resources for one or more subordinate entities (e.g., one or more other UEs). In this example, the UE is functioning as a scheduling entity, and other UEs utilize resources scheduled by the UE for wireless communication. A UE may function as a scheduling entity in a peer-to-peer (P2P) network, and/or in a mesh network. In a mesh network example, UEs may optionally communicate directly with one another in addition to communicating with the scheduling entity.

Thus, in a wireless communication network with a scheduled access to time-frequency resources and having a cellular configuration, a P2P configuration, and a mesh configuration, a scheduling entity and one or more subordinate entities may communicate utilizing the scheduled resources.

As noted above, a RAN may include a CU and DUs. A NR BS (e.g., eNB, 5G Node B, Node B, transmission reception point (TRP), access point (AP)) may correspond to one or multiple BSs. NR cells can be configured as access cell (ACells) or data only cells (DCells). For example, the RAN (e.g., a central unit or distributed unit) can configure the cells. DCells may be cells used for carrier aggregation or dual connectivity, but not used for initial access, cell selection/reselection, or handover. In some cases DCells may not transmit synchronization signals—in some case cases DCells may transmit SS. NR BSs may transmit downlink signals to UEs indicating the cell type. Based on the cell type indication, the UE may communicate with the NR BS. For example, the UE may determine NR BSs to consider for cell selection, access, handover, and/or measurement based on the indicated cell type.

FIG. **2** illustrates an example logical architecture of a distributed radio access network (RAN) **200**, which may be implemented in the wireless communication system illustrated in FIG. **1**. A 5G access node **206** may include an access node controller (ANC) **202**. The ANC may be a central unit (CU) of the distributed RAN **200**. The backhaul interface to the next generation core network (NG-CN) **204** may terminate at the ANC. The backhaul interface to neighboring next generation access nodes (NG-ANs) may terminate at the ANC. The ANC may include one or more TRPs **208** (which may also be referred to as BSs, NR BSs, Node Bs, 5G NBs, APs, or some other term). As described above, a TRP may be used interchangeably with "cell."

The TRPs **208** may be a DU. The TRPs may be connected to one ANC (ANC **202**) or more than one ANC (not illustrated). For example, for RAN sharing, radio as a service (RaaS), and service specific AND deployments, the TRP may be connected to more than one ANC. A TRP may include one or more antenna ports. The TRPs may be configured to individually (e.g., dynamic selection) or jointly (e.g., joint transmission) serve traffic to a UE.

The local architecture **200** may be used to illustrate fronthaul definition. The architecture may be defined that support fronthauling solutions across different deployment types. For example, the architecture may be based on transmit network capabilities (e.g., bandwidth, latency, and/or jitter).

The architecture may share features and/or components with LTE. According to aspects, the next generation AN (NG-AN) **210** may support dual connectivity with NR. The NG-AN may share a common fronthaul for LTE and NR.

The architecture may enable cooperation between and among TRPs **208**. For example, cooperation may be preset within a TRP and/or across TRPs via the ANC **202**. According to aspects, no inter-TRP interface may be needed/present.

According to aspects, a dynamic configuration of split logical functions may be present within the architecture **200**. As will be described in more detail with reference to FIG. **5**, the Radio Resource Control (RRC) layer, Packet Data Convergence Protocol (PDCP) layer, Radio Link Control (RLC) layer, Medium Access Control (MAC) layer, and a Physical (PHY) layers may be adaptably placed at the DU or CU (e.g., TRP or ANC, respectively). According to certain aspects, a BS may include a central unit (CU) (e.g., ANC **202**) and/or one or more distributed units (e.g., one or more TRPs **208**).

FIG. **3** illustrates an example physical architecture of a distributed RAN **300**, according to aspects of the present disclosure. A centralized core network unit (C-CU) **302** may host core network functions. The C-CU may be centrally deployed. C-CU functionality may be offloaded (e.g., to advanced wireless services (AWS)), in an effort to handle peak capacity.

A centralized RAN unit (C-RU) **304** may host one or more ANC functions. Optionally, the C-RU may host core network functions locally. The C-RU may have distributed deployment. The C-RU may be closer to the network edge.

A DU **306** may host one or more TRPs (edge node (EN), an edge unit (EU), a radio head (RH), a smart radio head (SRH), or the like). The DU may be located at edges of the network with radio frequency (RF) functionality.

FIG. **4** illustrates example components of the BS **110** and UE **120** illustrated in FIG. **1**, which may be used to implement aspects of the present disclosure. As described above, the BS may include a TRP. One or more components of the BS **110** and UE **120** may be used to practice aspects of the present disclosure. For example, antennas **452**, Tx/Rx **222**, processors **466**, **458**, **464**, and/or controller/processor **480** of the UE **120** and/or antennas **434**, processors **460**, **420**, **438**, and/or controller/processor **440** of the BS **110** may be used to perform the operations described herein and illustrated with reference to FIGS. **8-11**.

FIG. **4** shows a block diagram of a design of a BS **110** and a UE **120**, which may be one of the BSs and one of the UEs in FIG. **1**. For a restricted association scenario, the base station **110** may be the macro BS **110***c* in FIG. **1**, and the UE **120** may be the UE **120***y*. The base station **110** may also be a base station of some other type. The base station **110** may be equipped with antennas **434***a* through **434***t*, and the UE **120** may be equipped with antennas **452***a* through **452***r*.

At the base station **110**, a transmit processor **420** may receive data from a data source **412** and control information from a controller/processor **440**. The control information may be for the Physical Broadcast Channel (PBCH), Physical Control Format Indicator Channel (PCFICH), Physical Hybrid ARQ Indicator Channel (PHICH), Physical Downlink Control Channel (PDCCH), etc. The data may be for the Physical Downlink Shared Channel (PDSCH), etc. The processor **420** may process (e.g., encode and symbol map) the data and control information to obtain data symbols and control symbols, respectively. The processor **420** may also generate reference symbols, e.g., for the PSS, SSS, and cell-specific reference signal. A transmit (TX) multiple-input multiple-output (MIMO) processor **430** may perform spatial processing (e.g., precoding) on the data symbols, the control symbols, and/or the reference symbols, if applicable, and may provide output symbol streams to the modulators (MODs) **432***a* through **432***t*. Each modulator **432** may process a respective output symbol stream (e.g., for OFDM, etc.) to obtain an output sample stream. Each modulator **432** may further process (e.g., convert to analog, amplify, filter, and upconvert) the output sample stream to obtain a downlink signal. Downlink signals from modulators **432***a* through **432***t* may be transmitted via the antennas **434***a* through **434***t*, respectively.

At the UE **120**, the antennas **452***a* through **452***r* may receive the downlink signals from the base station **110** and may provide received signals to the demodulators (DEMODs) **454***a* through **454***r*, respectively. Each demodulator **454** may condition (e.g., filter, amplify, downconvert, and digitize) a respective received signal to obtain input samples. Each demodulator **454** may further process the input samples (e.g., for OFDM, etc.) to obtain received symbols. A MIMO detector **456** may obtain received symbols from all the demodulators **454***a* through **454***r*, perform MIMO detection on the received symbols if applicable, and provide detected symbols. A receive processor **458** may process (e.g., demodulate, deinterleave, and decode) the detected symbols, provide decoded data for the UE **120** to a data sink **460**, and provide decoded control information to a controller/processor **480**. According to one or more cases, CoMP aspects can include providing the antennas, as well as some Tx/Rx functionalities, such that they reside in distributed units. For example, some Tx/Rx processing can be done in the central unit, while other processing can be done at the distributed units. For example, in accordance with one or more aspects as shown in the diagram, the BS mod/demod **432** may be in the distributed units.

On the uplink, at the UE **120**, a transmit processor **464** may receive and process data (e.g., for the Physical Uplink Shared Channel (PUSCH)) from a data source **462** and control information (e.g., for the Physical Uplink Control Channel (PUCCH) from the controller/processor **480**. The transmit processor **464** may also generate reference symbols for a reference signal. The symbols from the transmit processor **464** may be precoded by a TX MIMO processor **466** if applicable, further processed by the modulators **454***a* through **454***r* (e.g., for SC-FDM, etc.), and transmitted to the base station **110**. At the BS **110**, the uplink signals from the UE **120** may be received by the antennas **434**, processed by the demodulators **432**, detected by a MIMO detector **436** if applicable, and further processed by a receive processor **438** to obtain decoded data and control information sent by the UE **120**. The receive processor **438** may provide the decoded data to a data sink **439** and the decoded control information to the controller/processor **440**.

The controllers/processors **440** and **480** may direct the operation at the base station **110** and the UE **120**, respectively. The processor **440** and/or other processors and modules at the base station **110** may perform or direct, e.g., the processes for the techniques described herein. The processor **480** and/or other processors and modules at the UE **120** may also perform or direct, e.g., execution of the functional blocks illustrated in FIG. **9**, and/or other processes for the techniques described herein. The memories **442** and **482** may store data and program codes for the BS **110** and the UE **120**, respectively. A scheduler **444** may schedule UEs for data transmission on the downlink and/or uplink.

FIG. **5** illustrates an example of a micro sleep procedure. Each time interval **505** may correspond a unit of downlink transmission from a BS **110** to a UE **120** comprising a control channel **510** and a data channel **515**. In particular, the time interval **505** may be a subframe, slot, or a mini-slot and may comprise of multiple OFDM symbols. The time interval **505** may be a schedule unit. Each time interval **505** may contain a downlink control channel (CCH) **510** and a downlink data channel (DCH) **515**. The downlink CCH, which includes scheduling information for UEs may be transmitted using the first one, two, or three ODFM symbols. Traffic data may be transmitted in the remaining OFDM symbols **515**.

A UE **120** may not be able to demodulate and decode the CCH immediately upon reception of CCH. The UE **120** may take multiple symbols, e.g., 2, 4, or more symbols, to demodulate and decode after all the CCH symbols **510***a* are received. Thus, at **520**, multiple symbols after **510***a*, UE **120** may finish demodulating and decoding the CCH and may know whether it is scheduled to receive traffic data in DCH. If data traffic is scheduled for UE **120**, the UE **120** demodulates and decodes the data in the remainder of the time interval **505**. During this process, reference symbols appearing in the data traffic portion may be collected and incorporated into the ongoing channel estimation process.

However, if it is determined that there is no data scheduled for the UE **120**, then there is a potential for portions of the receiver, such as one or more radio frequency (RF) components, to be turned off to save power until the reception of the next CCH. UE **120** may sleep during the time interval **525**. This turning off of the RF component during the time interval **525** is called micro sleep. Although short, micro sleep when applied to multiple time intervals may provide meaningful reduction in UE's power consumption.

It may be desirable to enter sleep mode earlier than **520** to enhance UE's power saving. In particular, if the time interval **505** is short compared to CCH **510** and/or if demodulating and decoding the CCH **510** incurs long delay, the benefit of micro sleep for UE's power consumption may be reduced. Hence, it may be desirable for a UE to enter micro sleep earlier for increased reduction in power consumption.

Example Power Saving by Detecting Empty Symbols

During connected mode, a UE may utilize the micro sleep procedure to conserve power by sleeping during a portion of DCH. However, time duration of micro sleep may begin only after the UE determines that the DCH is not destined to it which requires the UE to demodulate and decode the CCH. Demodulating and decoding the CCH may require multiple symbols during which micro sleep is delayed. It may be desirable for a UE to enter sleep mode earlier to conserve power.

In certain aspects, delay in entering micro sleep is due to the time that a UE needs to ascertain whether DCH will be allocated or scheduled to the UE which requires demodulating and decoding the CCH. However, in an environment where a BS uses multiple beams (e.g., narrow analog beams) to cover an area, such as high band frequencies (e.g., mmW), a UE may ascertain whether DCH will be allocated or scheduled to the UE based on determining whether a beam is directed to the UE. For example, a UE may determine that a beam is not directed to it by measuring the beam energy and comparing the beam energy measurement to a threshold.

In certain aspects, a UE may enter a sleep mode as soon as the UE determines that there is no beam directed to the UE and when there is no prior DCH assignment to the UE for the current time interval.

Entering sleep mode based on measurement of beam energy and prior DCH assignment to the UE may reduce UE's power consumption because it may allow the UE to enter sleep earlier than the micro sleep procedure. The UE may enter sleep mode immediately after receiving CCH or even earlier. In addition, entering sleep mode based on measurement of beam energy and prior DCH assignment to the UE may allow the UE to skip blind decoding of CCH if no signal is detected. Skipping decoding of CCH may reduce digital processing which may further reduce UE's power consumption.

FIG. **6** illustrates an example operation **600** for power conserving by detecting empty symbols. In certain aspects, operation **600** illustrated in FIG. **6** may be done by a UE **120**. According to the operation **600** in FIG. **6**, in step **605**, a UE may measure beam energy from a base station during a first portion of a time interval. In an aspect, the time interval may be a subframe, a slot, or a mini-slot. In an aspect, the first portion of a time interval may comprise a set of symbols indicating control information. For example, the first portion of a time interval may be a set of PDCCH or ePDCCH symbols.

According to the operation **600** in FIG. **6**, in step **610**, the UE may determine a lack of prior resource allocation to the UE for the time interval. In certain aspects, the UE may determine that a BS did not assign downlink resources for the current time interval in prior time intervals. For example, the BS may allocate recurring and/or persistent downlink resources to the UE in prior time intervals. For example, the BS may also allocate a non-persistent downlink resource to the UE in a prior time interval but spanning to the current time interval. A UE may determine whether such prior allocation of downlink resources affecting the current time interval were present in prior time intervals.

According to the operation **600** in FIG. **6**, in step **615**, the UE may enter a sleep mode for a second portion of the time interval based at least on the measured beam energy and the determination of a lack of prior resource allocation for the current time interval. In certain aspects, a sleep mode may comprise of selectively de-activating a set of radio frequency (RF) components. In an aspect, a second portion of the time interval may be all or portion of the time interval after making the determination. For example, the second portion may be the downlink data traffic portion of the time interval. For example, the second portion may include a portion of the downlink CCH and the downlink data traffic portion of the time interval.

In certain aspects, in step **615**, the UE may enter a sleep mode based at least on the measured beam energy and the determination of a lack of prior resource allocation for the current time interval. In an aspect, the measured beam energy may indicate that the beam is not directed to the UE. For example, the measured beam energy may be below a particular threshold indicative that the beam is not directed to the UE. For example, the measured beam energy may indicate a detection of empty symbols. A beam not directed to the UE may indicate that there is no downlink traffic allocated to the UE. A UE with indication that a beam is not directed to it together with determination that there is no prior resource allocation may provide assurance that there is no downlink traffic allocated to it without demodulating and decoding downlink CCH.

In certain aspects, the UE may enter sleep mode based additionally on a measurement of signal compared to a measurement of noise. In an aspect, a measurement of signal compared to a measurement of noise may be signal to noise ratio (SNR). For example, assuming a condition regarding the measured beam energy and the lack of prior resource allocation has been satisfied, the UE may enter a sleep mode when the SNR is good, e.g., SNR>10 dB. Good SNR may enable the UE to more easily detect whether the beam is directed to it or not as the signal would be more easily distinguishable from the thermal noise floor.

In certain aspects, the UE may enter sleep mode for subsequent time intervals in addition to the current time interval if the measured beam energy is below a threshold and there is no resource allocation for the subsequent time intervals. For example, the UE may additionally enter sleep for the next time interval if the measured beam energy is indicative that the beam will not be directed to the UE for the current and the next time interval.

Various operations **600** of FIG. **6** may be performed by a UE **120** in FIG. **4**. In particular, block **605** may be performed by antennas **452**, a receive processor **458**, and/or a controller/processor **480**. Block **610** may be performed by a receive processor **458**, and/or a controller/processor **480**. Block **615** may be performed by a receive processor **458**, and/or a controller/processor **480**.

The methods disclosed herein comprise one or more steps or actions for achieving the described method. The method steps and/or actions may be interchanged with one another without departing from the scope of the claims. In other words, unless a specific order of steps or actions is specified, the order and/or use of specific steps and/or actions may be modified without departing from the scope of the claims.

Moreover, the term "or" is intended to mean an inclusive "or" rather than an exclusive "or." That is, unless specified otherwise, or clear from the context, the phrase, for example, "X employs A or B" is intended to mean any of the natural inclusive permutations. That is, for example the phrase "X employs A or B" is satisfied by any of the following instances: X employs A; X employs B; or X employs both A and B. As used herein, reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." For example, the articles "a" and "an" as used in this application and the appended claims should generally be construed to mean "one or more" unless specified otherwise or clear from the context to be directed to a singular form. Unless specifically stated otherwise, the term "some" refers to one or more. A phrase referring to "at least one of" a list of items refers to any combination of those items, including single members. As an example, "at least one of: a, b, or c" is intended to cover: a, b, c, a-b, a-c, b-c, and a-b-c, as well as any combination with multiples of the same element (e.g., a-a, a-a-a, a-a-b, a-a-c, a-b-b, a-c-c, b-b, b-b-b, b-b-c, c-c, and c-c-c or any other ordering of a, b, and c). As used herein, including in the claims, the term "and/or," when used in a list of two or more items, means that any one of the listed items can be employed by itself, or any combination of two or more of the listed items can be employed. For example, if a composition is described as containing components A, B, and/or C, the composition can contain A alone; B alone; C alone; A and B in combination; A and C in combination; B and C in combination; or A, B, and C in combination.

As used herein, the term "determining" encompasses a wide variety of actions. For example, "determining" may include calculating, computing, processing, deriving, investigating, looking up (e.g., looking up in a table, a database or another data structure), ascertaining and the like. Also, "determining" may include receiving (e.g., receiving information), accessing (e.g., accessing data in a memory) and the like. Also, "determining" may include resolving, selecting, choosing, establishing and the like.

The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but are to be accorded the full scope consistent with the language claims. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims.

The various operations of methods described above may be performed by any suitable means capable of performing the corresponding functions. The means may include various hardware and/or software component(s) and/or module (s), including, but not limited to a circuit, an application specific integrated circuit (ASIC), or processor. Generally, where there are operations illustrated in figures, those operations may have corresponding counterpart means-plus-function components with similar numbering.

For example, means for transmitting and/or means for receiving may comprise one or more of a transmit processor **420**, a TX MIMO processor **430**, a receive processor **438**, or antenna(s) **434** of the base station **110** and/or the transmit processor **464**, a TX MIMO processor **466**, a receive processor **458**, or antenna(s) **452** of the user equipment **120**. Additionally, means for obtaining, means for designating, means for aggregating, means for collecting, means for selecting, means for switching, and means for detecting may comprise one or more processors, such as the controller/processor **480**, transmit processor **464**, receive processor **458**, and/or MIMO processor **466** of the user equipment **120**.

The various illustrative logical blocks, modules and circuits described in connection with the present disclosure may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device (PLD), discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any commercially available processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

If implemented in hardware, an example hardware configuration may comprise a processing system in a wireless node. The processing system may be implemented with a bus architecture. The bus may include any number of interconnecting buses and bridges depending on the specific application of the processing system and the overall design constraints. The bus may link together various circuits including a processor, machine-readable media, and a bus interface. The bus interface may be used to connect a network adapter, among other things, to the processing system via the bus. The network adapter may be used to implement the signal processing functions of the PHY layer. In the case of a user terminal **120** (see FIG. **1**), a user interface (e.g., keypad, display, mouse, joystick, etc.) may also be connected to the bus. The bus may also link various other circuits such as timing sources, peripherals, voltage regulators, power management circuits, and the like, which are well known in the art, and therefore, will not be described any further. The processor may be implemented with one or more general-purpose and/or special-purpose processors. Examples include microprocessors, microcontrollers, DSP processors, and other circuitry that can execute software. Those skilled in the art will recognize how best to implement the described functionality for the processing system depending on the particular application and the overall design constraints imposed on the overall system.

If implemented in software, the functions may be stored or transmitted over as one or more instructions or code on a computer readable medium. Software shall be construed broadly to mean instructions, data, or any combination thereof, whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise. Computer-readable media include both computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. The processor may be responsible for managing the bus and general processing, including the execution of software modules stored on the machine-readable storage media. A computer-readable storage medium may be coupled to a processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. By way of example, the machine-readable media may include a transmission line, a carrier wave modulated by data, and/or a computer readable storage medium with instructions stored thereon separate from the wireless node, all of which may be accessed by the processor through the bus interface. Alternatively, or in addition, the machine-readable media, or any portion thereof, may be integrated into the processor, such as the case may be with cache and/or general register files. Examples of machine-readable storage media may include, by way of example, RAM (Random Access Memory), flash memory, phase change memory, ROM (Read Only Memory), PROM (Programmable Read-Only Memory), EPROM (Erasable Programmable Read-Only Memory), EEPROM (Electrically Erasable Programmable Read-Only Memory), registers, magnetic disks, optical disks, hard drives, or any other suitable storage medium, or any combination thereof. The machine-readable media may be embodied in a computer-program product.

A software module may comprise a single instruction, or many instructions, and may be distributed over several different code segments, among different programs, and across multiple storage media. The computer-readable media may comprise a number of software modules. The software modules include instructions that, when executed by an apparatus such as a processor, cause the processing system to perform various functions. The software modules may include a transmission module and a receiving module. Each software module may reside in a single storage device or be distributed across multiple storage devices. By way of example, a software module may be loaded into RAM from a hard drive when a triggering event occurs. During execution of the software module, the processor may load some of the instructions into cache to increase access speed. One or more cache lines may then be loaded into a general register file for execution by the processor. When referring to the functionality of a software module below, it will be understood that such functionality is implemented by the processor when executing instructions from that software module.

Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared (IR), radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, include compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk, and Blu-ray® disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Thus, in some aspects computer-readable media may comprise non-transitory computer-readable media (e.g., tangible media). In addition, for other aspects computer-readable media may comprise transitory computer-readable media (e.g., a signal). Combinations of the above should also be included within the scope of computer-readable media.

Thus, certain aspects may comprise a computer program product for performing the operations presented herein. For example, such a computer program product may comprise a computer-readable medium having instructions stored (and/or encoded) thereon, the instructions being executable by one or more processors to perform the operations described herein.

Further, it should be appreciated that modules and/or other appropriate means for performing the methods and techniques described herein can be downloaded and/or otherwise obtained by a user terminal and/or base station as applicable. For example, such a device can be coupled to a server to facilitate the transfer of means for performing the methods described herein. Alternatively, various methods described herein can be provided via storage means (e.g., RAM, ROM, a physical storage medium such as a compact disc (CD) or floppy disk, etc.), such that a user terminal and/or base station can obtain the various methods upon coupling or providing the storage means to the device. Moreover, any other suitable technique for providing the methods and techniques described herein to a device can be utilized.

It is to be understood that the claims are not limited to the precise configuration and components illustrated above. Various modifications, changes and variations may be made in the arrangement, operation and details of the methods and apparatus described above without departing from the scope of the claims.

What is claimed is:

1. A method of wireless communication performed by a user equipment (UE), comprising:
- measuring a beam energy from a serving base station (BS) during a first portion of a time interval;
- determining no beam is directed to the UE based on the measuring and without decoding a control channel;
- determining a lack of resource allocation in a second time interval to the UE for the time interval, wherein the second time interval is prior to the time interval; and
- entering a sleep mode for a second portion of the time interval in response to the determining no beam is directed to the UE and the determining a lack of resource allocation in the second time interval.

2. The method of claim **1**, wherein the time interval is one of a subframe, a slot, or a mini-slot.

3. The method of claim **1**, wherein the first portion comprises a set of symbols indicating control information.

4. The method of claim **3**, wherein the set of symbols is a physical downlink control channel.

5. The method of claim **1**, wherein determining no beam is direct to the UE comprise comparing the measured beam energy to a threshold.

6. The method of claim **1**, wherein the sleep mode comprises selectively de-activating radio frequency (RF) components of the UE.

7. The method of claim **1**, wherein entering a sleep mode is further based on a measurement of signal compared to a measurement of noise.

8. The method of claim **1**, further comprising: entering a sleep mode for a next time interval after the time interval based on determining the measured beam energy is below a threshold and a lack of resource allocation in the second time interval to the UE for the next time interval.

9. A user equipment (UE) for wireless communication, comprising:
- a memory; and
- at least one processor coupled to the memory and configured to:
  - measure a beam energy from a serving base station (BS) during a first portion of a time interval;
  - determine no beam is directed to the UE based on the measuring and without decoding a control channel;
  - determine a lack of resource allocation in a second time interval to the UE for the time interval, wherein the second time interval is prior to the time interval; and
  - enter a sleep mode for a second portion of the time interval in response to the determination no beam is directed to the UE and the determination the lack of resource allocation in the second time interval.

10. The UE of claim **9**, wherein the time interval is one of a subframe, a slot, or a mini-slot.

11. The UE of claim **9**, wherein the first portion comprises a set of symbols indicating control information.

12. The UE of claim **11**, wherein the set of symbols is a physical downlink control channel.

13. The UE of claim **9**, wherein determining no beam is direct to the UE comprise comparing the measured beam energy to a threshold.

14. The UE of claim **9**, wherein the sleep mode comprises selectively de-activating radio frequency (RF) components of the UE.

15. The UE of claim **9**, wherein entering a sleep mode is further based on a measurement of signal compared to a measurement of noise.

16. The UE of claim **9**, the at least one processor is further configured to: enter a sleep mode for a next time interval after the time interval based on determining the measured beam energy is below a threshold and a lack of resource allocation in the second time interval to the UE for the next time interval.

17. An apparatus for wireless communication by a user equipment (UE), comprising:
- means for measuring a beam energy from a serving base station (BS) during a first portion of a time interval;

means for determining no beam is directed to the UE based on the measuring and without decoding a control channel;

means for determining a lack of resource allocation in a second time interval to the UE for the time interval, wherein the second time interval is prior to the time interval; and

means for entering a sleep mode for a second portion of the time interval the in response to the determining no beam is directed to the UE and the determining a lack of resource allocation in the second time interval.

18. The apparatus of claim **17**, wherein the time interval is one of a subframe, a slot, or a mini-slot.

19. The apparatus of claim **17**, wherein the first portion comprises a set of symbols indicating control information.

20. The apparatus of claim **19**, wherein the set of symbols is a physical downlink control channel.

21. The apparatus of claim **17**, wherein determining no beam is direct to the UE comprise comparing the measured beam energy to a threshold.

22. The apparatus of claim **17**, wherein the sleep mode comprises selectively de-activating radio frequency (RF) components of the UE.

23. The apparatus of claim **17**, wherein entering a sleep mode is further based on a measurement of signal compared to a measurement of noise.

24. The apparatus of claim **17**, further comprising: means for entering a sleep mode for a next time interval after the time interval based on determining the measured beam energy is below a threshold and a lack of resource allocation in the second time interval to the UE for the next time interval.

25. A non-transitory computer readable medium storing code for wireless communication, the code comprising instructions executable by a processor to:

measure a beam energy from a serving base station (BS) during a first portion of a time interval;

determine no beam is directed to the UE based on the measuring and without decoding a control channel;

determine a lack of resource allocation in a second time interval to the UE for the time interval, wherein the second time interval is prior to the time interval; and

enter a sleep mode for a second portion of the time interval in response to the determination no beam is directed to the UE and the determination the lack of resource allocation in the second time interval.

26. The non-transitory computer-readable medium of claim **25**, wherein the first portion comprises a set of symbols indicating control information.

27. The non-transitory computer-readable medium of claim **25**, wherein entering a sleep mode is based at least on the measured beam energy indicative of a beam not directed to the UE.

28. The non-transitory computer-readable medium of claim **25**, wherein the sleep mode comprises selectively de-activating radio frequency (RF) components of the UE.

29. The non-transitory computer-readable medium of claim **25**, wherein determining no beam is direct to the UE comprise comparing the measured beam energy to a threshold.

30. The non-transitory computer-readable medium of claim **25**, further comprising: enter a sleep mode for a next time interval after the time interval based on determining the measured beam energy is below a threshold and a lack of resource allocation in the second time interval to the UE for the next time interval.

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